Creating MIDI Files with binasc

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1 February 2018

Download binasc

(install Hombrew from http://brew.sh first)

In /Applications/Utilities/Terminal.app, type:

```
git clone http://github.com/craigsapp/binasc
cd binasc
make
make install
```

Binasc means binary ⟺ ascii

A form of hex editor: https://en.wikipedia.org/wiki/Hex_editor

Hex byte codes to actual bytes

4d 54 68 64 00 00 00 06 00 00 00 01 00 80 4d 54 72 6b 00 00 00 8c 00 ff 58
04 04 02 30 08 00 ff 59 02 00 00 00 90 3c 28 81 00 90 3c 00 00 90 3c 1e 81
00 90 3c 00 00 90 43 2d 81 00 90 43 00 00 90 43 32 81 00 90 43 00 00 90 45
2d 81 00 90 45 00 00 90 45 32 81 00 90 45 00 00 90 43 23 82 00 90 43 00 00
90 41 32 81 00 90 41 00 00 90 41 2d 81 00 90 41 00 00 90 40 32 40 90 40 00
40 90 40 28 40 90 40 00 40 90 3e 2d 40 90 3e 00 40 90 3e 32 40 90 3e 00 40
90 3c 1e 82 00 90 3c 00 00 ff 2f 00

binasc file.txt -c file.mid

-C → compile the output into file.mid

Lowest level

Hex byte codes are the most direct representation of a MIDI file's contents:

```
4d 54 68 64 00 00 00 06 00 00 00 01 00 80 4d 54 72 6b 00 00 00 8c 00 ff 58
04 04 02 30 08 00 ff 59 02 00 00 00 90 3c 28 81 00 90 3c 00 00 90 3c 1e 81
00 90 3c 00 00 90 43 2d 81 00 90 43 00 00 90 43 32 81 00 90 43 00 00 90 45
2d 81 00 90 45 00 00 90 45 32 81 00 90 45 00 00 90 43 23 82 00 90 43 00 00
90 41 32 81 00 90 41 00 00 90 41 2d 81 00 90 41 00 00 90 40 32 40 90 40 00
40 90 40 28 40 90 40 00 40 90 3e 2d 40 90 3e 00 40 90 3e 32 40 90 3e 00 40
90 3c 1e 82 00 90 3c 00 00 ff 2f 00
```

But this is not very readable for humans…

Next level of abstraction

Using the *binasc* syntax for alternate representation of bytecodes

"MThd" → 4d 54 68 64

Use bytecode of ASCII printable character

4'6 → 00 00 00 06

Four-byte value for decimal number 6

2'1 → 00 01

Two-byte value for decimal number 1

'60 → 3c

One-byte value for decimal number 60

v128 → 81 00 v0 → 00

Variable-length-value for decimal number 128

Linebreaks are not important, just for readability.

```
"MThd"
4'6
2'0
2'1
2'128
"MTrk"
4'140
v0      ff 58 v4 '4 '2 '48 '8
v0      ff 59 v2 '0 '0
v0      90 '60 '40
v128    90 '60 '0
v0      90 '60 '30
v128    90 '60 '0
v0      90 '67 '45
v128    90 '67 '0
v0      90 '67 '50
v128    90 '67 '0
v0      90 '69 '45
v128    90 '69 '0
v0      90 '69 '50
v128    90 '69 '0
v0      90 '67 '35
v256    90 '67 '0
v0      90 '65 '50
v128    90 '65 '0
v0      90 '65 '45
v128    90 '65 '0
v0      90 '64 '50
v64     90 '64 '0
v64     90 '64 '40
v64     90 '64 '0
v64     90 '62 '45
v64     90 '62 '0
v64     90 '62 '50
v64     90 '62 '0
v64     90 '60 '30
v256    90 '60 '0
v0      ff 2f v0
```

Patch (instrument) Change

http://www.ccarh.org/courses/253/handout/gminstruments

Patch change Message:

C_ #

"General MIDI" specifies 128 instruments:

Subtract 1

Piano Timbres:

1 Acoustic Grand Piano
2 Bright Acoustic Piano
3 Electric Grand Piano
4 Honky-tonk Piano
5 Rhodes Piano
6 Chorused Piano
7 Harpsichord
8 Clavinet

Brass Timbres:

57 Trumpet
58 Trombone
59 Tuba
60 Muted Trumpet
61 French Horn
62 Brass Section
63 Synth Brass 1
64 Synth Brass 2

```
"MThd"
4'6
2'0
2'1
2'128
"MTrk"
4'143
v0      ff 58 v4 '4 '2 '48 '8
v0      ff 59 v2 '0 '0
v0      c0 60
v0      90 '60 '40
v128    90 '60 '0
v0      90 '60 '30
v128    90 '60 '0
v0      90 '67 '45
v128    90 '67 '0
v0      90 '67 '50
v128    90 '67 '0
v0      90 '69 '45
v128    90 '69 '0
v0      90 '69 '50
v128    90 '69 '0
v0      90 '67 '35
v256    90 '67 '0
v0      90 '65 '50
v128    90 '65 '0
v0      90 '65 '45
v128    90 '65 '0
v0      90 '64 '50
v64     90 '64 '0
v64     90 '64 '40
v64     90 '64 '0
v64     90 '62 '45
v64     90 '62 '0
v64     90 '62 '50
v64     90 '62 '0
v64     90 '60 '30
v256    90 '60 '0
v0      ff 2f v0
```

General MIDI drum sounds

- Channel 10 is reserved for percussion sounds in General MIDI
- "Channel 10" → 9 in MIDI command-byte channel nibble
- Note-on command byte: 0x99

- Each key on the percussion channel represents a different instrument:

35	Acoustic Bass Drum	51	Ride Cymbal 1	67	High Agogo
36	Bass Drum 1	52	Chinese Cymbal	68	Low Agogo
37	Side Stick	53	Ride Bell	69	Cabasa
38	Acoustic Snare	54	Tambourine	70	Maracas
39	Hand Clap	55	Splash Cymbal	71	Short Whistle
40	Electric Snare	56	Cowbell	72	Long Whistle
41	Low Floor Tom	57	Crash Cymbal 2	73	Short Guiro
42	Closed High Hat	58	Vibraslap	74	Long Guiro
43	High Floor Tom	59	Ride Cymbal 2	75	Claves
44	Pedal High Hat	60	High Bongo	76	High Wood Block
45	Low Tom	61	Low Bongo	77	Low Wood Block
46	Open High Hat	62	Mute High Conga	78	Mute Cuica
47	Low Mid Tom	63	Open High Conga	79	Open Cuica
48	High Mid Tom	64	Low Conga	80	Mute Triangle
49	Crash Cymbal 1	65	High Timbale	81	Open Triangle
50	High Tom	66	Low Timbale		

- Play the cowbell: 99 '56 '64
- Drum sounds do not require note-off message

Polyrhythm in Type-1 MIDI files

- Binasc operator t: MIDI tempo
- Convert from tempo into 3-byte microsecond value

ff 51 03 **t40** → ff 51 03 **16 e3 60**

0x16e360 = 1,500,000 microseconds
= 1.5 seconds per beat
60/1.5 = 40 beats/minute

- Ticks-per-quarter notes set to 6 (LCM of 2 and 3)

Expression track

Track 1

Track 2

```
"MThd"
4'6
2'1
2'3
2'6

"MTrk"
4'11
v0 ff 51 03 t40
v0 ff 2f 00

"MTrk"
4'28
v0   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v0   ff  2f  00

"MTrk"
4'24
v0   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v0   ff  2f  00
```

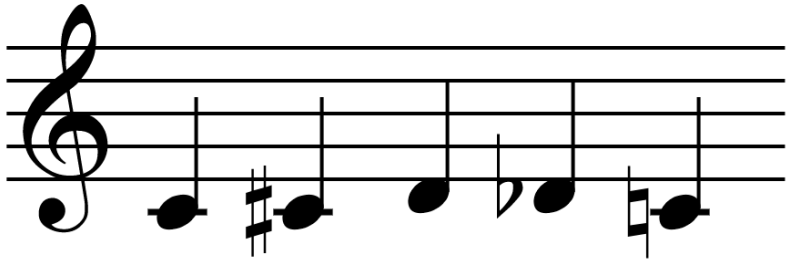
Polyrhythm in Type-0 MIDI file

```
"MThd"
4'6
2'1
2'3
2'6


"MTrk"
4'11
v0 ff 51 03 t40
v0 ff 2f 00


"MTrk"
4'28
v0   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v2   99 '76 '64
v0   ff  2f  00


"MTrk"
4'24
v0   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v3   99 '77 '64
v0   ff  2f  00
```

```
"MThd"
4'6
2'0
2'1
2'6

"MTrk"
4'55

v0   ff 51 03 t40
v0   99 '76 '64
v0   99 '77 '64
v2   99 '76 '64
v1   99 '77 '64
v1   99 '76 '64
v2   99 '76 '64
v0   99 '77 '64
v2   99 '76 '64
v1   99 '77 '64
v1   99 '76 '64
v2   99 '77 '64
v0   ff 2f 00
```

Accidentals (MIDI-plus)

```
"MThd"
4'6
2'0
2'1
2'120

"MTrk"
4'44
v0   90 '60 0110,1010
v120 80 '60 0
v0   90 '61 0110,1010
v120 80 '61 0
v0   90 '62 0110,1010
v120 80 '62 0
v0   90 '61 0110,1001
v120 80 '61 0
v0   90 '60 0110,1010
v120 80 '60 0
v120 ff 2f v0
```



Value	Key Number/Pitch Value											
	60	61	62	63	64	65	66	67	68	69	70	71
0	pitch spelling undetermined											
1	D𝄫	D𝄭	E𝄫	F𝄫	F𝄭	G𝄫	G𝄭	A𝄫	A𝄭	B𝄫	C𝄫	C𝄭
2	C	C♯	D	E𝄭	E	F	F♯	G	G♯	A	B𝄭	B
3	B♯	B♯♯	C♯♯	D♯	D♯♯	E♯	E♯♯	F♯♯	F♯♯♯	G♯♯	A♯	A♯♯

Pitchbend

Binasc syntax: **p** followed by a floating-point number in the range from -1.0 to +1.0 is converted into the two data bytes for MIDI pitch bend messages.

MIDI Pitch Bend Message:

E_ lsb msb

E_ = hex byte code starting with nibble “E”.
lsb = least significant 7 bits of value
msb = most significant 7 bits of value

```
p-1    → 00 00 → 000,0000;000,0000 = 0
p-0.5  → 00 20 → 010,0000;000,0000 = 4096
p0     → 00 40 → 100,0000;000,0000 = 8192
p0.5   → 7f 5f → 101,1111;111,1111 = 12287
p1     → 7f 7f → 111,1111;111,1111 = 16383
```

Pitch bend range is programmable (depending on synth), but typical default range is +/- 200 cents (+/- 2 semitones).

```
"MThd"
4'6
2'0
2'1
2'100

"MTrk"
4'72

v0    90 '60 '100
v90   80 '60 '100

v10   e0 p0.5
v0    90 '59 '100
v90   80 '59 '100

v10   e0 p-0.5
v0    90 '61 '100
v90   80 '61 '100

v10   e0 p1
v0    90 '58 '100
v90   80 '58 '100

v10   e0 p-1
v0    90 '62 '100
v90   80 '62 '100

v10   e0 p0
v0    90 '60 '100
v90   80 '60 '100

v0    ff 2f 00
```

Glissandos/Vibrato

```
"MThd"
4'6
2'0
2'1
2'100

"MTrk"
4'66

v0   ff 51 03 t40
v0   e0 p0.0
v0   c0 '71          ; clarinet
v0   90 '60 64
v20  e0 p0.05
v10  e0 p0.10
v10  e0 p0.15
v10  e0 p0.20
v10  e0 p0.25
v10  e0 p0.30
v10  e0 p0.35
v10  e0 p0.40
v10  e0 p0.45
v10  e0 p0.50
v30  80 '60 00
v0   ff 2f 00
```

Temperament

Quarter-comma meantone

```
v0      e0 '0   '64
v0      e1 '41  '56
v0      e2 '105 '61
v0      e3 '38  '67
v0      e4 '79  '59
v0      e5 '11  '65
v0      e6 '56  '57
v0      e7 '117 '62
v0      e8 '30  '55
v0      ea '90  '60
v0      eb '23  '66
v0      ec '68  '58
```

Pitch-class	Cent deviation from ET
c	0
c#	-24.0
d	-6.8
e-	+10.3
e	-13.7
f	+3.4
f#	-20.5
g	-3.4
a-	-27.4
a	-10.3
b-	+6.8
b	-17.1

Equal temperament

Meantone

Temperament (2)

Kirnberger III

```
v0      e0 '0   '64
v0      e1 '112 '60
v0      e2 '104 '61
v0      e3 '16  '62
v0      e4 '79  '59
v0      e5 '48  '63
v0      e6 '112 '60
v0      e7 '116 '62
v0      e8 '64  '61
v0      ea '92  '60
v0      eb '96  '62
v0      ec '32  '60
```

Pitch-class	Cent deviation from ET
c	0
c#	-9.775
d	-6.843
e-	-5.865
e	-13.686
f	-1.955
f#	-9.776
g	-3.422
a-	-7.82
a	-10.265
b-	-3.91
b	-11.73

Temperament (3)

Pythagorean

```
v0      e0 '0   '64
v0      e1 '49  '68
v0      e2 '32  '65
v0      e3 '16  '62
v0      e4 '64  '66
v0      e5 '48  '63
v0      e6 '96  '67
v0      e7 '80  '64
v0      e8 '64  '61
v0      ea '112 '65
v0      eb '96  '62
v0      ec '16  '67
```

Pitch-class	Cent deviation from ET
c	0
c#	13.7
d	3.9
e-	-5.9
e	7.8
f	-1.96
f#	11.7
g	1.96
a-	-7.8
a	5.87
b-	-3.9
b	9.8

Temperament (4)

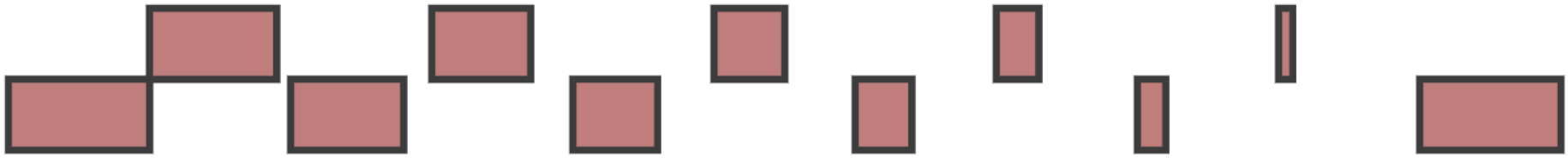
Vallotti

```
v0      e0 '118 '65
v0      e1 '0   '64
v0      e2 '82  '64
v0      e3 '36  '65
v0      e4 '46  '63
v0      e5 '72  '66
v0      e6 '46  '63
v0      e7 '36  '65
v0      e8 '82  '64
v0      ea '0   '64
v0      eb '118 '65
v0      ec '92  '62
```

Pitch-class	Cent deviation from ET
c	+6
c#	0
d	+2
e-	+4
e	-2
f	+8
f#	-2
g	+4
a-	+2
a	0
b-	+6
b	-4

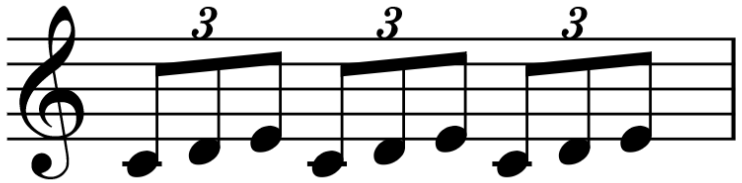
Staccato

```
"MThd"
4'6
2'0
2'1
2'100

"MTrk"
4'95

v0   c0 '19
v0   90 '60 64
v100 80 '60 64
v0   90 '61 64
v90  80 '61 64
v10  90 '60 64
v80  80 '60 64
v20  90 '61 64
v70  80 '61 64
v30  90 '60 64
v60  80 '60 64
v40  90 '61 64
v50  80 '61 64
v50  90 '60 64
v40  80 '60 64
v60  90 '61 64
v30  80 '61 64
v70  90 '60 64
v20  80 '60 64
v80  90 '61 64
v10  80 '61 64
v90  90 '60 64
v100 80 '60 64
v0   ff 2f 00
```



Ticks per Quarter & Round-off Error

```
"MThd"
4'6
2'0
2'1
2'128

"MTrk"
4'76

v0    90 '60 64
v43   80 '60 64
v0    90 '62 64
v43   80 '62 64
v0    90 '64 64
v42   80 '64 64

v0    90 '60 64
v43   80 '60 64
v0    90 '62 64
v43   80 '62 64
v0    90 '64 64
v42   80 '64 64

v0    90 '60 64
v43   80 '60 64
v0    90 '62 64
v43   80 '62 64
v0    90 '64 64
v42   80 '64 64

v128 ff 2f 00
```



```
"MThd"
4'6
2'0
2'1
2'120

"MTrk"
4'76

v0    90 '60 64
v40   80 '60 64
v0    90 '62 64
v40   80 '62 64
v0    90 '64 64
v40   80 '64 64

v0    90 '60 64
v40   80 '60 64
v0    90 '62 64
v40   80 '62 64
v0    90 '64 64
v40   80 '64 64

v0    90 '60 64
v40   80 '60 64
v0    90 '62 64
v40   80 '62 64
v0    90 '64 64
v40   80 '64 64

v120 ff 2f 00
```

Continuous controllers

General MIDI controller numbers:
http://www.ccarh.org/courses/253/handout/controllers

Controller 10 (zero offset) is stereo pan left/right

0
left

127
right

```
"MThd"
4'6
2'1
2'3
2'100

"MTrk"
4'76

v0   b9 '10 '0
v0   99 '60 '90
v100 b9 '10 '16
v0   99 '60 '90
v100 b9 '10 '32
v0   99 '60 '90
v100 b9 '10 '48
v0   99 '60 '90
v100 b9 '10 '64
v0   99 '60 '90
v100 b9 '10 '80
v0   99 '60 '90
v100 b9 '10 '96
v0   99 '60 '90
v100 b9 '10 '112
v0   99 '60 '90
v100 b9 '10 '127
v0   99 '60 '90

v0 ff 2f 00
```

Attack velocity versus Main volume

```
"MThd"
4'6
2'0
2'1
2'200
"MTrk"
4'80
v0   99 '60 '10
v100 99 '60 '20
v100 99 '60 '30
v100 99 '60 '40
v100 99 '60 '50
v100 99 '60 '60
v100 99 '60 '70
v100 99 '60 '80
v100 99 '60 '90
v100 99 '60 '100
v100 99 '60 '110
v100 99 '60 '120
v100 99 '60 '127
v100 99 '60 '110
v100 99 '60 '90
v100 99 '60 '70
v100 99 '60 '50
v100 99 '60 '30
v100 99 '60 '10
v0   ff  2f  00
```

```
"MThd"
4'6
2'0
2'1
2'200
"MTrk"
4'156
v0   b9 07 '10   v0  99 '60 '127
v100 b9 07 '20   v0  99 '60 '127
v100 b9 07 '30   v0  99 '60 '127
v100 b9 07 '40   v0  99 '60 '127
v100 b9 07 '50   v0  99 '60 '127
v100 b9 07 '60   v0  99 '60 '127
v100 b9 07 '70   v0  99 '60 '127
v100 b9 07 '80   v0  99 '60 '127
v100 b9 07 '90   v0  99 '60 '127
v100 b9 07 '100  v0  99 '60 '127
v100 b9 07 '110  v0  99 '60 '127
v100 b9 07 '120  v0  99 '60 '127
v100 b9 07 '127  v0  99 '60 '127
v100 b9 07 '110  v0  99 '60 '127
v100 b9 07 '90   v0  99 '60 '127
v100 b9 07 '70   v0  99 '60 '127
v100 b9 07 '50   v0  99 '60 '127
v100 b9 07 '30   v0  99 '60 '127
v100 b9 07 '10   v0  99 '60 '127
v0   ff  2f  00
```

How to cheat at counting bytes

In Terminal.app, use the “wc” command to count the number of bytes within a track.

Step 1: compile your MIDI file with binasc

```
binasc myfile.txt −c myfile.mid
```

Step 2: decompile your MIDI file into hex bytes

```
binasc myfile.mid > bytecodes.txt
```

Step 3: pull out the bytes of a track (easy if a type-0 MIDI file, otherwise search for next “MTrk” tag and/or ff 2f 00 end-of-track marker) and save to separate text file. Then use wc to count the “words” in the file:

```
wc -w trackbytes.txt
```

Step 4: take that number and put into track size field of original file, myfile.txt

Homework 5b

- Create a MIDI file with at least 25 MIDI messages
- Incorporate at least 4 of the following features into the MIDI file:
    - Type-1 MIDI file (multi-track)
    - Patch change (timbre/instrument change)
    - Pitch bend (glissandos, temperament)
    - Articulations (accents, staccato/legato)
    - Continuous controller (master volume, pan)
    - Meta message (tempo, key signature, time signature, track name)
    - Percussion sounds
    - Chords
- Send me a copy of the MIDI file by next Thursday's class so we can play them.